

Workshop Report

Trust of EO data and uncertainty

Speaker: Marc Paganini (ESA)

Facilitation: Rolf Maier-Bode (Design & Data)

Co-Facilitation: Nina Hofer (Statistics Austria)

StatEO26, May 7

ESRIN, Frascati (RM)

Workshop · Impressions



Workshop Exercises · Board impressions





Workshop Exercises · Overview

1. Wind

What propels us forward
at present?



2. Anchor + Vote

What holds us back
at present?

3. HMW

"How might we..." rephrasing

Turning
voted anchors
into solvable challenges

+

Vote on most important
HMW challenge to solve.

4. Ideation

Finding solutions to HMWs

using
rotation of boards

+

Peer vote

The session ran four exercises in sequence. Each exercise built on the previous one — what *works* today framed what is *broken*; the most-voted breakage became a *How Might We* question; rotating peer ideation answered those questions.

Workshop Exercises · Output in numbers

Exercise	Items	Votes	Clusters
Wind (what works)	94	—	7
Anchors (what blocks)	113	106	7
HMW (the reframed challenge)	59	80	6
Ideation (what we'd do)	211	84	7
	477	270	

Overall: 477 post-its and 270 votes across four exercises.

Opening Speaker: Marc Paganini (ESA)

Before the silent exercises began, Marc Paganini opened the workshop by setting the trust question formally. The frame on screen was deliberate: trust in EO for official statistics was approached not as a sentiment problem but as a quality-system problem, anchored to the same standards by which official statistics are themselves judged.

The workshop was asked to engage with six guiding sub-questions:

1. What factors build or erode trust in EO data when used in official statistics?
2. How can we ensure transparency and reproducibility of EO workflows?
3. How should uncertainty be quantified and communicated?
4. What are the best practices for metadata and documentation?
5. Which frameworks for data quality assessment are needed?
6. How can EO products become not only scientifically robust but trusted, accepted, and usable within official statistical frameworks?

The session was placed against the *UN Fundamental Principles of Official Statistics* and the *European Statistics Code of Practice* — the quality regimes EO products must eventually pass through if they are to enter the statistical record. From the seven UN Principles surfaced on screen, one was held up as the operative test of trust:

Principle 3 — Accountability & Transparency: *“Can we understand and reproduce the EO-derived statistics?”*

This single question framed the sailboat that followed.

The Value Chain — Where Trust Can Be Built

The opening also made visible why trust is hard to engineer: four distinct actor layers sit between a satellite measurement and a published official statistic, each contributing — and each potentially eroding — confidence at its own step.



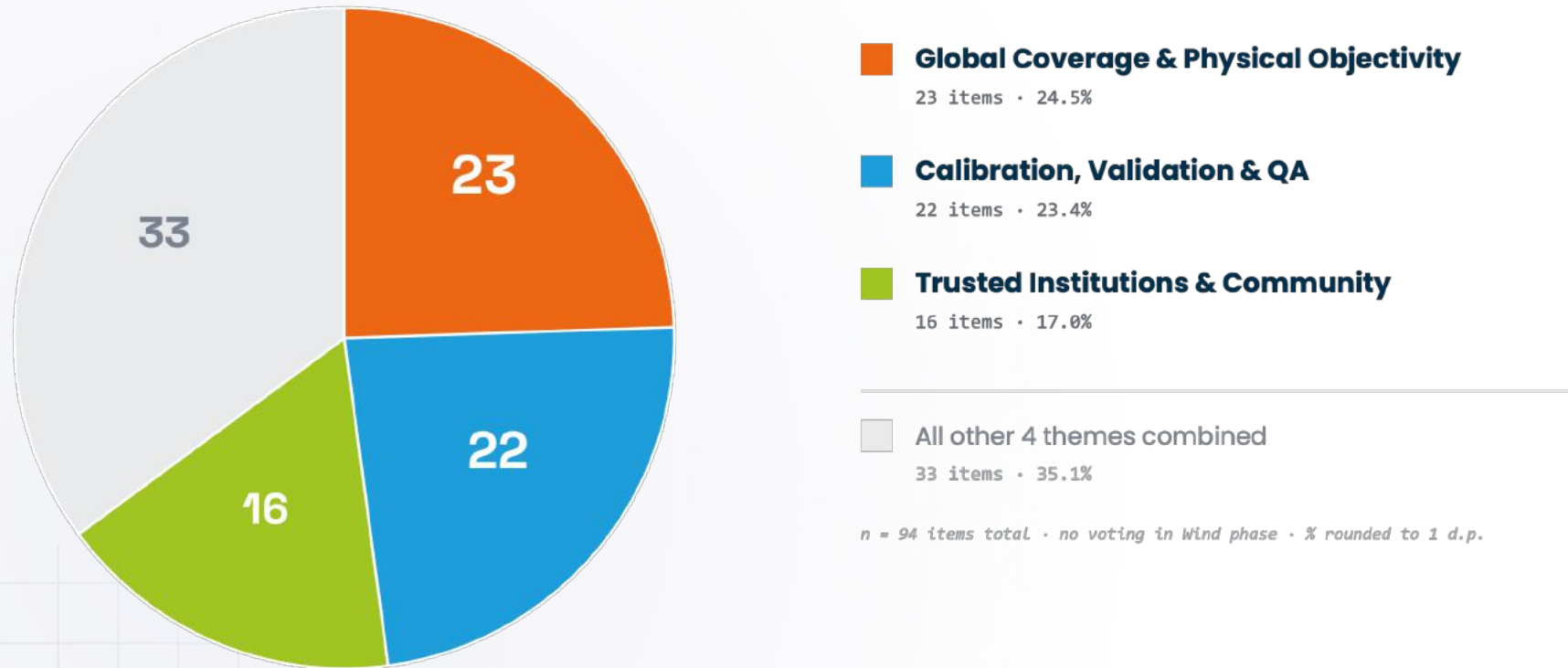
The Value Chain — Where Trust Is Built or Eroded

Trust in the final published statistic is no stronger than the weakest layer in this chain.

**The workshop's task — and the post-its the room produced —
can be read as a layer-by-layer diagnosis of where the chain holds and where it slips.**

1. Wind — what is working today

Hot themes — three currents carry two-thirds of the wind



All three say one thing: trust today rests on external endorsement — physics, validated process, and reputable institutions.

1. Wind — what was specifically said

Global Coverage & Physical Objectivity (23 items)

- It exists with universal geographic coverage.
- I trust EO data because it is a physical representation of the environment
- Objective across countries and borders

Calibration, Validation & QA (22 items)

- Rigorous instruments and thorough calibration creates confidence in its output.
- Available, accepted best practice recommendations to quantify uncertainty
- It comes with an uncertainty / reliability layer

Trusted Institutions & Community (16 items)

- Many trusted organisations advocate for using EO data
- Directly from EU ♥
- Trust in the institutions providing the data

Documentation, Transparency & Traceable Processing (12 items)

- Reproducible and documented pipelines from sensor to pixels
- Traceable Processing Through Value Chain
- Transparency & accountability of the full production chain

1. Wind — what was specifically said

Long Time Series & Mission Continuity (8 items)

- Long time series / consistency of longer products + missions
- Missions have been operating and measuring for many years (like S-1, S-2)
- Years of R&D goes into the development and continuous improvements of sensors. (Literally rocket scientists)

Open & Free Access (7 items)

- Open source & open access -> good documentation
- Open access - publicly available
- Free, open & transparent data

Technical Performance & Versatility (6 items)

- Technology has increased exponentially over the past decade (AI, ML)
- Diversity of data
- Scalable

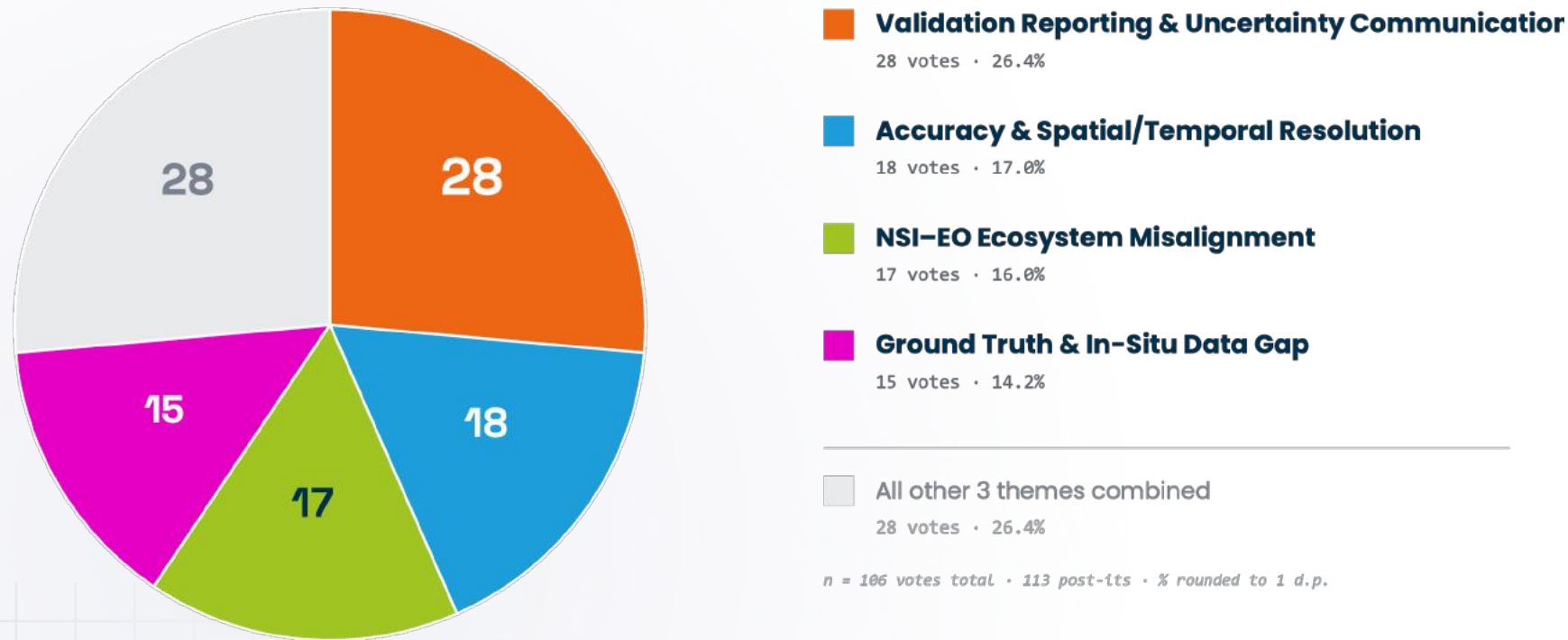
Wind paints a confident picture: the EO *supply side* is in good shape — physics, calibration, peer review, open access and trusted producers are in place. Wind is the floor the rest of the workshop builds on.

Items and Shares of all Cluster

Cluster	Items	Share
Global Coverage & Physical Objectivity	23	24.5%
Calibration, Validation & QA	22	23.4%
Trusted Institutions & Community	16	17.0%
Documentation, Transparency & Traceable Processing	12	12.8%
Long Time Series & Mission Continuity	8	8.5%
Open & Free Access	7	7.4%
Technical Performance & Versatility	6	6.4%

2. Anchors — what the room voted as blocking trust

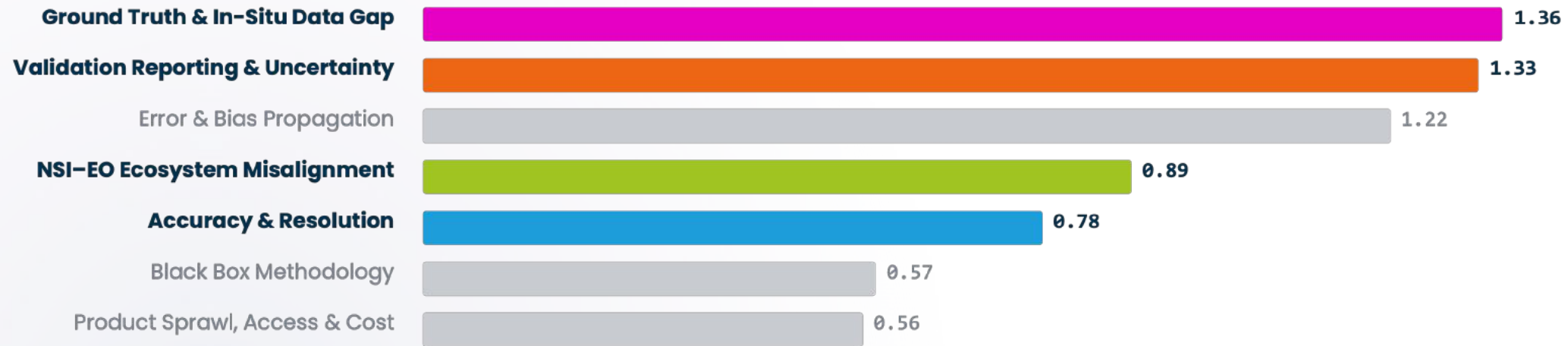
Top 4 by absolute votes



Validation Reporting & Uncertainty Communication takes 26.4% of the room's votes — almost double the fourth-place cluster. The next three (Resolution, NSI Misalignment, Ground Truth) sit close together; together with the leader they carry 73.6% of all votes.

2. Anchors — which blockers are felt most intensely

Same room, different ranking — votes per post rearrange the top



V/P = votes per post-it • colors match pie identity • n = 7 clusters • 106 votes across 113 post-its

Ground Truth jumps from #4 by votes to #1 by intensity (1.36 votes per item) — fewer post-its, but each strongly endorsed.
Resolution drops the other way: many items, thin endorsement per item.
Black Box drops too: frequently named, not deeply felt.

Footnote. Top 4 by absolute votes. Cluster #5 (Black Box, 12 votes) sits just below the cut-off — see V/P view.

2. Anchors — what was specifically said

Validation Reporting & Uncertainty Communication

28 votes • 26.4% • 21 post-its

8

Lack of validation or uncertainties information from the maps producers.

5

Uncertainty range missing

5

What validation has been done? Where has it been done?

NSI-EO Ecosystem Misalignment & Cultural Inertia

17 votes • 16.0% • 19 post-its

4

Understand the ecosystem

2

Different actors, different meanings on concepts / language ontologies

2

NSIs trust traditional stats more — even if it is not always right

Accuracy & Spatial/Temporal Resolution

18 votes • 17.0% • 23 post-its

5

Low accuracies of such EO products.

3

Not accurate enough for my purpose

2

Difficulty in temporal time comparison as products evolve

Ground Truth & In-Situ Data Gap

15 votes • 14.2% • 11 post-its

5

(Lack of) sufficient ground truth data

4

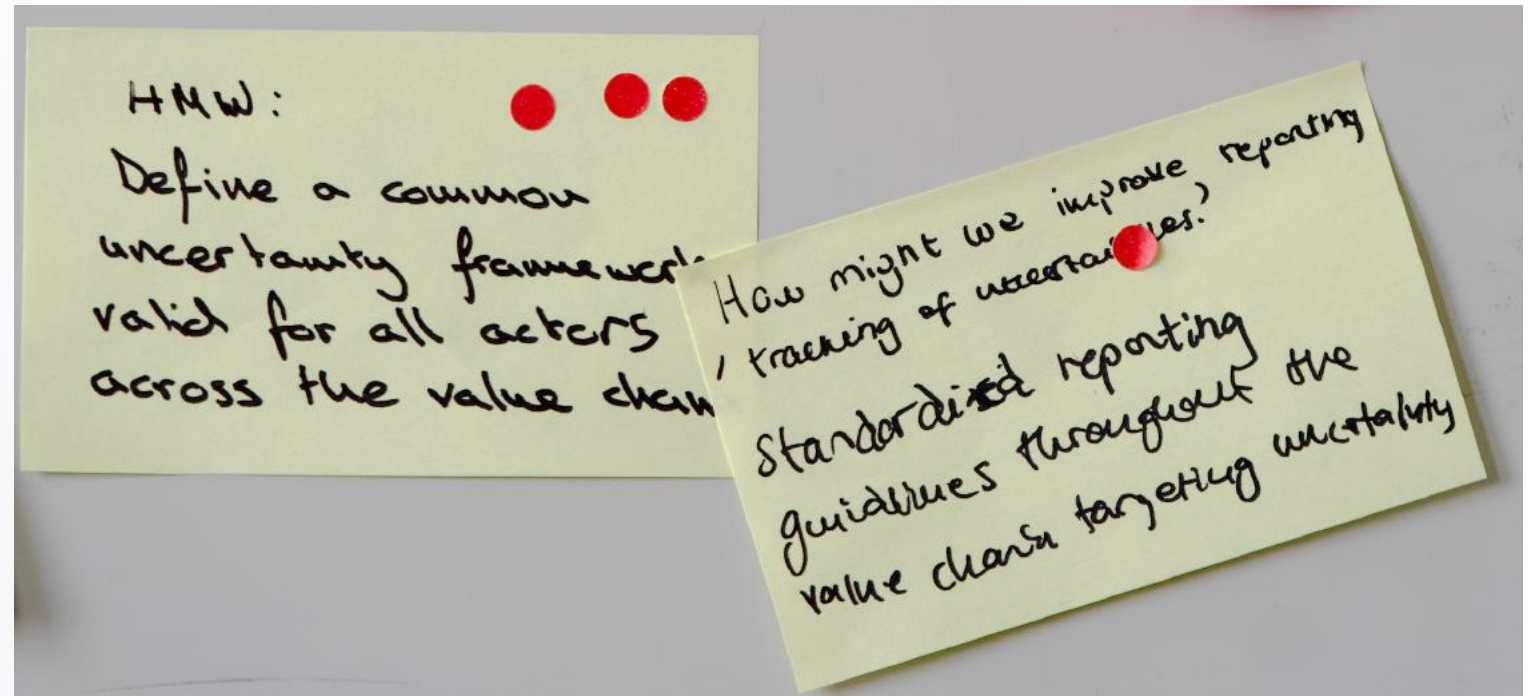
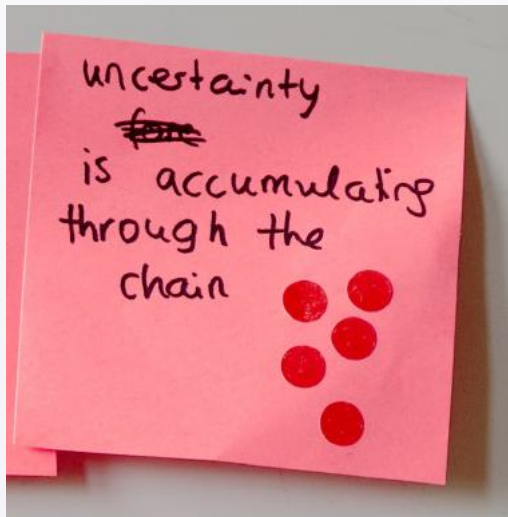
Lack of in-situ data for validation of data gaps

3

Lack of calibration with ground-truth data

3. How Might We — what the community asked itself

“How Might We...” questions are the starting point for finding solutions.



Each station turned its top-voted Anchor into an actionable "How Might We..." question, then voted on the best framing.

59 HMW post-its, 80 votes. Most HMWs stayed close to the anchor that drove them; a few escaped to broader systemic asks.

3. How Might We – clusters by votes



The HMW phase reads like a coherent ask list: standardise the reporting of validation and uncertainty (28.8%), build globally representative ground truth (20.0%), make production transparent (15.0%), bridge the EO–NSI language gap (13.8%). Unusually convergent for a workshop output.

Footnote. Votes are absolute dot counts aggregated across all 5 boards. N= 6 clusters. Cluster definitions are post-hoc; alternative groupings are possible.

3. How Might We — the winning HMWs

Five boards, six distinct framings*. The shared territory they fall into is visible one slide back — here are the specific questions each board chose to ask.

6

HMW... find the sweet spot between sharing uncertainty maps + validation and not dragging down the data sources, making all sides comfortable?

EO ⇌ NSI Communication

6

HMW... get clear specs how EO data/product has been produced

Production Transparency

5

HMW... ensure ground truth data collection is representative (e.g. not just European) globally?

Ground Truth Global Coverage

5

HMW... ensure that uncertainty is known & findable for all regions of the EO product?

Uncertainty Framework

5

HMW... find a way to support the accessibility of the in situ data reducing duplicity of resources cost effectiveness!

In-Situ Access

5

HMW produce uncertainty levels with enough confidence to insert EO at the statistics workflows?

Validation Standards

*one of the five boards had two tied #1s

4. Ideation — what we'd actually do

Vote-weighted Ideation clusters — standards dominate

Cluster	Items	Votes	Share	V/P
Standards, Frameworks & Reporting Templates	67	37	44.0%	0.55
Co-Design, User Engagement & Cross-Community Dialogue	34	14	16.7%	0.41
Mandates, Contracts & Funding	40	10	11.9%	0.25
Tools, Catalogues, Repositories & Hubs	26	9	10.7%	0.35
Uncertainty Visualisation & Flagging	15	8	9.5%	0.53
Capacity, Education & Awareness	18	5	6.0%	0.28
Validation Practices & Certification	11	1	1.2%	0.09

One cluster carries 44% of all ideation votes: *Standards, Frameworks & Reporting Templates*. Given complete freedom to propose any solution, participants chose — by a landslide — to write standards.

The next two clusters are also revealing: Co-Design & Dialogue (16.7%) — talk to each other; Mandates, Contracts & Funding (11.9%) — enforce it through procurement and money. Together with Standards, these three "lever" clusters account for 72.6% of ideation votes.

4. Ideation — the top-voted ideas across all clusters

6	Spatial accuracy estimate	Uncertainty Vis
5	Agree on what "uncertainty" is!	Standards
4	Standardised reporting guidelines framework on uncertainty and EO data across the value chain	Standards
4	Following standard ATBD template	Standards
4	Shorter (Summary) version of ATBD report (ESA)	Standards
4	Extend well-established in-situ networks (e.g. ICOS)	Tools
3	Uncertainty communication to the inexperienced end-user	Co-Design
3	Work with end users and understand their needs	Co-Design
3	Funding	Mandates
3	Creating recognition an incentive to provide & share data to data providers	Mandates
3	Recognized guideline of validation part of project requirements.	Standards
3	Ensure that uncertainty is propagated across the value chain with standardized protocols	Standards

12 of 211 ideas · 3+ votes · cluster colors = top 4 clusters by total votes · gray = Uncertainty Visualisation (#5 by votes, holds the #1 idea)

Meta analysis · same theme, four lenses

From "what already works" to "what we'd actually do" — validation, uncertainty and the standards around them stay center stage in every exercise, and their share grows.



share of dominant cluster within each exercise · Wind = item-share (no voting), others = vote-share · same theme, four vocabularies, growing concentration

The vocabulary shifts from phase to phase. The target does not.

Meta analysis · the EO–NSI cultural seam

A second theme tracks consistently at second place across every exercise — the institutions that produce EO are trusted, the institutions that consume it speak a different language.



share of secondary cluster within each exercise · Wind = item-share (no voting), others = vote-share · consistent 14–17% across four phases – convergence without growth

*The fix the community proposes is sociological, not technical:
co-design from the start, working groups, shared vocabulary.*

Meta analysis · **ground truth** — the invisible floor

The foundation everyone agrees is missing, but no one credits as a force already working



Invisible as a force, prominent as a gap, scattered as a fix.

Meta analysis · the thesis

Trust in EO for official statistics is treated as

a quality-of-process problem,

not a quality-of-data problem.

evidence across the four exercises

Wind

calibration & validation

23.4%

Anchors

absent validation

26.4%

HMW

reporting standards

28.8%

Ideation

frameworks & templates

44.0%

The community is not asking for new EO. It is asking for the rigour of the best EO products to become the floor — documented, reported and applied uniformly across the value chain.

Thank You for being part of this workshop!

Special thanks to **Marc Paganini** for the introduction and
Nina Hofer for co-facilitating this workshop together with Rolf Maier-Bode.



Got Questions / Feedback ?
Reach Out



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Appendices A-D

Appendix A • Wind

94 items • no voting phase • 5 boards (1-3, 5, 6)

Appendix B • Anchors

113 items • 106 votes • 5 boards (1-3, 5, 6)

Appendix C • HMW (How Might We questions)

59 items • 80 votes across 5 boards

Appendix D • Ideation

211 items • 84 votes across 6 sub-boards (Board 5 split into 5A and 5B)

Board 1 (20 items)

The different processing levels of EO data + provided products
Constant development of missions and data portal
Diversity of data
Collected in the same way globally + publically available
High quality of data
Radiometric consistency
Synoptic and repetitive performances
Long time series / consistency of longer products + missions
Peer-reviewed and assessed datasets
Variety of different data
Rigorous instruments and thorough calibration creates confidence in its output.
Pixel-based uncertainty characterisation
High quality instruments and processing chains to use analysis ready data e.g. Sentinels
It exists with universal geographic coverage.
Technology has increased exponentially over the past decade (AI, ML)
There are many EO companies providing data -> competition -> willingness to be the best -> better data
Worry about the past years and there will be data in the future.
There is sufficient peer review in the international community, checking and using EO data.
Open source & open access -> good documentation
Many trusted organisations advocate for using EO data

Board 2 (17 items)

I trust EO because overall is well documented.
Validation against in situ data is performed and reported
Missions have been operating and measuring for many years (like S-1, S-2)
Standardized and continuous data provision, with transparent methodology
Objective data Physically measured + validated
understanding how EO is collected / measured helps giving you trust on it to use it.
I trust EO data because it is a physical representation of the environment
Open access - publicly available
Directly from EU ♥
long-term investment in continuation of the data
Objective across countries and borders
Monitoring objectively
Geography and maps
Up-to-date - quick revisit times
Captures the spatial dimension of phenomena/processes
Traceable Processing Through Value Chain
1. Because I worked with EO for 25 years !

Appendix A · Wind

Board 3 (18 items)

Lots of research with EO data with benchmarks and validation
Years of R&D goes into the development and continuous improvements of sensors.
(Literally rocket scientists)
A thorough explanation of how to interpret the product
Reproducible and documented pipelines from sensor to pixels
I trust it because I know its limitations / I understand it
EO data produced by state institution
Objective validation of accuracy and errors.
EO raw data is objective data source.
Somehow a bit useful to support existing processes
Known issues problems and limitations
Spatial & temporal coverage
Available, accepted best practice recommendations to quantify uncertainty
Global and (mostly) consistent
Validated global datasets.
Trusted sources of information
It relates directly to well known local environments
Recommendations of the good practices (IPCC etc) to integrate them for reporting.
Open data access allows reproducing results

Board 5 (17 items, Board 4 was not used)

that are used by trusted institutions (EU, UN...)
validation reports
L4 products rely on in-situ data
physical properties based
Willingness to support other sectors integrating those datasets
Spatial and temporal consistent Good for change monitoring
Cost effectiveness
producer's reputation
global coverage
Scientific methodological accuracy and guidelines (GHG concentrations)
It comes with an uncertainty / reliability layer
Validation results are good.
validation
long term experience
cross validations between sources
a certain level of reproducibility
Scalable

Appendix A · Wind

Board 6 (22 items)

Accessibility
High number & frequency of data
If I see others using it effectively
final users involved in product definition & specification
↑ Availability of high resolution data
Interoperable metadata
Spatial coverage
High frequency
Compatibility & agreement between existing products
Continuity
Flexibility to adapt to national definitions
Real measures (L1+L2)
Temporal coverage
When results are peer reviewed
EO products (mostly) from authorized source
Robust, scientific QAQC
Trust in the institutions providing the data
Transparent & traceable production
Transparency & accountability of the full production chain
Free open data
Free, open & transparent data
(Most) data is open (can be verified)

Board 1 (21 items · 19 votes)

- 5v · (Lack of) sufficient ground truth data**
- 2v · Policymakers & NSI complain about the inconsistency between official statistics and estimates from EO (geospatial) data.**
- 2v · Uncertainty assessment for spec. applications e.g. combining multiple EO products → bias propagation**
- 2v · Use of A.I models without information about test or quality metrics**
- 2v · Lack of evidence that EO data are more cost-effective than other type of data**
- 2v · Sufficient understanding of spectral resolution for monitoring objects**
- 1v · Limited ground truth data in underrepresented regions**
- 1v · Indirect measurements and proxies for things not directly observable**
- 1v · Black box issue (not knowing how data processing works)**
- 1v · Mixed pixels / insufficient resolution for the task that has to be solved**
- 0v · Lack of ground truth, references for calibrate and validate
- 0v · There is a lack of a global approach to collecting & managing ground truth data
- 0v · Gaps between EO and ground data.
- 0v · Lack of spatially-explicit uncertainty information, accompanying EO data.
- 0v · Results derived from EO-data products (e.g. copernicus HRL products) do not show high enough accuracy.
- 0v · Robustness of gap-filling methods
- 0v · How to treat clouds – missing data
- 0v · NSI's don't have the capacity to derive custom products for national use cases
- 0v · Difficulties in cross-calibration of multiple EO datasets e.g. for time series
- 0v · Difficult to access certain data
- 0v · Difficulty in integrating EO data in already existing workflows

Board 2 (19 items · 17 votes)

- 5v · Uncertainty is accumulating through the chain**
- 3v · Too many data sources/options. Difficult to decide what is best to use for your goal.**
- 3v · Metadata traceability through Value Chain**
- 2v · Results are not always comparable with those from traditional methods**
- 2v · Not trusting EO-based global products as its not clear how good its performance is at the national/regional scale**
- 2v · Outputs from EO do don't match the indicators that I want to report**
- 0v · For how long will the service exist?
- 0v · There are too many different flavours / versions of the same variable eg. LCLU
- 0v · There is an explosion of AI-driven product that are not validated.
- 0v · VHR EO data is too expensive or hard to acquire
- 0v · Human in the loop introduces subjective decisions
- 0v · Just describing a method doesn't necessarily mean it is robust, transferable, ...
- 0v · Metadata more complex following the value chain – and often info is missing –
- 0v · New products/solutions lack calibration/validation in my Area of Interest
- 0v · Gap in Last Mile of Value Chain
- 0v · Hard to know how much of the final product is interpolated and gap filled
- 0v · Not all EO data products are generated with full uncertainties.
- 0v · Data reliability
- 0v · Data doesn't always have adequate uncertainty characterisation

Appendix B · Anchors

Board 3 (22 items · 21 votes)

- 8v · Lack of validation or uncertainties information from the maps producers.**
- 5v · Low accuracies of such EO products.**
- 2v · Lower resolution misses details**
- 2v · Errors in classification.**
- 1v · Reference data not suited for validation**
- 1v · Missing updated high quality in situ info & data**
- 1v · The detailed documentation on the way the dataset was produced.**
- 1v · Capacity to inform on the considered subject**
- 0v · Missing quality information
- 0v · Reporting on uncertainties doesn't align with good/best practices.
- 0v · It is difficult to associate errors, e.g. NDVI value $\pm$???
- 0v · Accuracy metrics cannot be reproduced due to data privacy issues
- 0v · Missing communication on accuracy metrics and their calculation
- 0v · Missing "standard" validation process.
- 0v · Lack of transparent information on accuracy, methods, sources
- 0v · Unclear processing workflow.
- 0v · Constant clouds in certain areas
- 0v · If there are too many NAs in the datasets
- 0v · Easier / cheaper alternatives
- 0v · Too complex classification
- 0v · 10m resolution is not suitable for every application e.g. urbanization
- 0v · Lack of consistency or coherent information

Board 5 (23 items · 26 votes)

- 5v · too high accuracies reported**
- 5v · Uncertainty range missing**
- 4v · Understand the ecosystem**
- 4v · lack of in-situ data for validation of data gaps**
- 2v · NSIs trust traditional stats more – even if it is not always right**
- 2v · Different actors, different meanings on concepts / language ontologies**
- 1v · Non-repeatable results**
- 1v · Opaque methodologies and choices taken throughout (longer) value-chain**
- 1v · Testset Validation not independent.**
- 1v · no validation conducted**
- 0v · Statistical requirements are not aligned with EO data
- 0v · For some data only "authorized" users
- 0v · Lack of standardized methods
- 0v · Complexity to work with multiple actors
- 0v · That we are still missing an institutionalized uptake at national / EU level....
- 0v · Unknown pipeline
- 0v · Unknown source of input data
- 0v · Knowing the boundaries from data to value added services
- 0v · Errors do not tend to compensate (bias) (crop-type map)
- 0v · Bias correction should be improved
- 0v · Errors in in-situ data collection
- 0v · Not a relevant resolution for political action at local scales
- 0v · Clouds > gaps > interpolation > no real values (errors propagation)

Appendix B · Anchors

Board 6 (28 items · 23 votes)

5v · What validation has been done? Where has it been done?

3v · Used methodology unclear

3v · Lack of calibration with ground-truth data

3v · Not accurate enough for my purpose

2v · When EO products come from a "black box" process.

2v · Unclear communication of uncertainty associated w/ EO products

2v · Difficulty in temporal time comparison as products evolve

1v · Non-standardised methodologies in developing downstream EO-products/applications

1v · Lack of shared language between the EO & stat communities

1v · I trust it, but my management does not!

0v · Too many processing steps out of control.

0v · Not clear how these are produced (L4)

0v · What are the gaps & how are these treated (shortcomings)

0v · Transition from data to products

0v · No harmonized & consistent uncertainty/error information

0v · EO products imposing definitions

0v · Products that were validated with in-situ data, not fit-for-purpose

0v · Interpretation depends on interpreters consensus -> sometimes lack of consistency (subjectivity)

0v · No sanity checks (beyond validation) looking for conceptual differences

0v · Quality is not clear

0v · All important changes (e.g. peatlands)

0v · Not enough time to investigate & decide if I trust it.

0v · Statistics timelines have tight deadlines

0v · Inter-annual variability & short time series

0v · Not sure whether dataset will be produced in the near future

0v · Time series inconsistencies

0v · Not frequent enough.

0v · Lack of consistent (in space/time) information for some products, not enough data

Appendix C · HMW (How Might We questions)

Board 1 (12 items · 16 votes)

- 5v · HMW... ensure ground truth data collection is representative (e.g. not just European) globally?**
- 4v · HMW... go towards global ground truth databases accessible to all?**
- 3v · HMW advocate for an increased and improved ground-data collection at national and local level?**
- 2v · HMW as EO community join forces e.g. ecologist / institutions so ground sampling could benefit EO product validation**
- 1v · HMW... come to international agreement on the minimum data quality of ground truth data?**
- 1v · HMW find better ways to collect ground truth data e.g. easier ways for biodiversity assessments?**
- 0v · HMW... encourage sharing and full access to domain-specific ground truth data?
- 0v · HMW... produce large amounts of reliable and FAIR and standardized ground truth data?
- 0v · HMW... calibrate EO data using ground data?
- 0v · HMW.... faster implementation and maintenance of ground infrastructures for validate/calibrate E.O. data?
- 0v · HMW collect standardized, evenly spread (spatially) ground truth data?
- 0v · HMW share and integrate existing ground data (OS) for EO

Board 2 (12 items · 13 votes)

- 5v · HMW: Ensure that uncertainty is known & findable for all regions of the EO product?**
- 3v · HMW: Define a common uncertainty framework valid for all actors across the value chain**
- 2v · HMW communicate uncertainty to end-users? eg. statisticians**
- 1v · HMW derive uncertainties that can be understood easily?**
- 1v · HMWimprove reporting / tracking of uncertainties? Standardised reporting guidelines throughout the value chain targeting uncertainty**
- 1v · How do we avoid bias in the measurement?**
- 0v · How do we measure uncertainty?
- 0v · HMW... decide on adequate uncertainty measures?
- 0v · What is uncertainty?
- 0v · HMW generate uncertainties that can be used by the statistics community?
- 0v · HMW embed detailed uncertainty information, considering local/regional variability
- 0v · How might we... provide uncertainty with the product? -> i.e. in additional layers

Appendix C · HMW (How Might We questions)

Board 3 (11 items · 15 votes)

6v · HMW... Find the sweet spot between sharing uncertainty maps + validation and not dragging down the data sources, making all sides comfortable?

4v · HMW enforce following best-practice recommendations and communication of limitations

3v · HMW... integrate uncertainty information and processing information in the product (uncertainty per step? per pixel?)

1v · HMW... create & agree standards for accuracy reporting?

1v · HMW... find solutions if a product does not meet the target accuracy? Re-process? Not use it?

0v · HMW associate for each pixel (maybe) in the metadata an uncertainty estimation? (in accordance with every stakeholder)

0v · HMW... implement "standard validation workflow to report on errors and uncertainty" in the processing chain of the EO product?

0v · HMW... standardize the uncertainty reporting?

0v · HMW... increase capacity so users understand better the data?

0v · How can we make use of unprecise data in the statistical production & demonstrate the final added-value?

0v · HMW... follow common guidelines on reporting the uncertainties, making the products intercomparable.

Board 5 (14 items · 22 votes)

5v · HMW produce uncertainty levels with enough confidence to insert EO at the statistics workflows?

5v · HMW a way to support the accessibility of the in situ data reducing duplicity of resources cost effectiveness!

3v · HMW... provide standardized way of validation reporting?

2v · HMW create reliable accuracy and uncertainty estimates?

2v · HMW find better in-situ data for validation?

2v · Integrate in-situ data qualitative assessment to increase reliability

1v · How might we support validation practices for EO data?

1v · How might we create a baseline "accuracy" of uncertainty for EO services?

1v · HMW... make validation data more accessible?

0v · HMW... improve validation results?

0v · HMW Report method for ground data collection

0v · HMW increase the trust of EO data use?

0v · HMW... shift from EO model to map inference?

0v · HMW improve in-situ data & ground stations to improve EO products accuracy?

Appendix C · HMW (How Might We questions)

Board 6 (10 items · 14 votes)

6v · HMW... get clear specs how EO data/product has been produced

3v · HMW have overarching statistical standards for final EO-based products for all domains of application? (e.g. SEEA-EA)

1v · WMW... Collaborate as EO community to develop protocols on transparency

1v · HMW agree on a common transparent method / check list associated to each product

1v · HMW... make the steps from EO to product more transparent? (Maybe too broad?)

1v · HMW develop a shared vocabulary and language & work more closely together (EO – Stat)

1v · Actually the steps are all documented, so... HMW... make this visible to the stats community in a way that they will accept?

0v · WMW... Don't use / boycott / don't fund datasets that are not transparent

0v · ... the methods used to go from EO to product

0v · HMW: Include processing & methods better in metadata?

Board 1 (60 items · 20 votes)

HMW collect sufficient, standardized and spatially spread ground truth data and create a platform to share data (FAIR)

4v · Extend well-established in-situ networks (e.g. ICOS)

3v · Funding

2v · Minimum standards setting for all sort of ground truth data (official data, data collected through citizen science, ...)

2v · Community of practice – EO organisations + data collection agencies

2v · Provide funding for data collection and make data sharing obligatory by funding condition

1v · Periodic check-ins for updated ground-truth (UN / Regional entity?)

1v · Domain-specific ground truth data hubs e.g. – Zenodo community

1v · Capacity building for how to collect ground data (at country level)

1v · Gamification to excite collect data the wider public

1v · Global repository for ground truth data, submitted through NSIs

1v · We need an internationally agreed protocol for collecting in-situ data fit for EO integration

1v · Instead of human-interpret shift to AI reference collection (reduce cost)

0v · This is an idea that keeps being tried -> make the focus more on stats.

0v · Global program to fund ground-truth data collect & storing them

0v · International agreement on standardized classes

0v · Creation of incentives for countries to collect data

0v · Budgetary efforts for regional entities to collect and implement g.truth

0v · Link to Copernicus in-situ component

0v · Training of scientists/institutions on EO to incorporate their workflows for EO usage

0v · Funding for expert data labeling

0v · Create standard tool for collecting data

0v · ESA-supported 'citizen science' for EO programme app

0v · Funding for data cleaning

0v · Raise public awareness of necessity

0v · Citizen science training in schools -> how to excite next generation

0v · Domain-specific ground truth campaigns (like UCAS for agriculture)

0v · Standardized equipment shared across institutions doing surveys / data collection + sufficient training

0v · Clearly standardized collection workflows using checklists and sufficient funding for vehicles etc.

Board 1 continued

0v · Collaboration agreements

0v · Methodologies for standardization

0v · FSA as data host ensuring data collection, quality and accessibility -> leading institution (organizing)

0v · One in each country there is one clearly defined institution responsible for data collection + trained for standard assessment

0v · Develop EO reference data network

0v · Overview of gaps depending on case-study

0v · Develop common tool

0v · Surveys are expensive -> find how to finance them

0v · Consider lessons learned from past data collection efforts

0v · One application which is free (QField, etc) -> choose one

0v · Fund multi-purpose reference data

0v · Solutions when accessibility is an issue -> UAV?

0v · Refers to past Horizon projects efforts to collect data

0v · One database to collect all AQ data from ground monitoring stations globally

0v · Why not a Copernicus purchase system to service providers which are validating data

0v · E.U certified dataset, defining metadata etc

0v · Identifying a "custodian agency" for keeping all the data

0v · International collaboration workshops to align datasets/workflow databases

0v · Incentivizing data sharing

0v · Incentive mechanisms try to benchmark other incentivisations for data sharing

0v · Share & coordinate with other stakeholder groups

0v · StatEO website / repository for papers + input data of projects reported at conference

0v · Ensuring long-term availability and possible updates of the data

0v · Acknowledgment of data ownership to facilitate sharing

0v · Build international momentum & awareness on need for global repositories

0v · Make data-sharing mandatory in EU projects - through standard catalogues

0v · App built for data collection user cannot move on unless all fields are filled in; data automatically uploaded -> shared

0v · Try to bring onboard the European Research Infrastructures - ERIC -

0v · Financial compensation for data sharing (for NSOs)

0v · Review what is out there in terms of app and use them or adapt them if needed

0v · Continuity of existing efforts (e.g. World Cover)

0v · Establish a citizen science version of "ESA" - well-funded community supported

Board 2 (50 items · 24 votes)

HMW ensure that uncertainty is known and findable for all regions of the EO products throughout the value chain?

6v · Spatial accuracy estimate

5v · Agree on what "uncertainty" is!

4v · Standardised reporting guidelines framework on uncertainty and EO data across the value chain

3v · Uncertainty communication to the inexperienced end-user

1v · Educate EO community about statistical concepts

1v · Provide an online tool to facilitate validation with local data across the value chain

1v · Common guidelines value chain error propagation

1v · Cost considerations

1v · Clearly state scale / application data is suitable for + why. Resolution too low for regional studies

1v · Quantify how well uncertainty performs (e.g. PICP)

0v · Promote dialogue: EO practitioner, NSI, metrology, users

0v · Define uncertainty communication strategy — what are we saying?

0v · Find an appropriate measure

0v · Why quantify / communicate uncertainty at each step of production?

0v · Detailed and understandable explanation of what uncertainty means for non-technical users

0v · Provide pixel-wise uncertainty calculated against historical statistics

0v · Clarify measures for what uncertainty measures are needed.

0v · Regional actors in the uncertainty provision

0v · Generate long historical time series to facilitate validation against past statistics.

0v · Uncertainty from EO products intercomparison

0v · Only validating the end product

0v · Provide detailed info on map calibration (e.g. what ground data was used)

0v · If model-derived include flags based on applicability domain

0v · Visualize confidence intervals with the products (for continuous data)

0v · Produce uncertainty estimates disaggregated

0v · Pixel "flags" for data with high uncertainty OR gap-filled/AI (not direct observation)

0v · Provide info on where the data might not perform well in the metadata description

0v · Come to agreements between experts on how to develop uncertainty for all EO data.

0v · Provide uncertainty products

Board 2 continued

0v · Available / provide infrastructure to collect/store and share with standards

0v · Targeting aspects of EO uncertainty at each stage of the value chain

0v · Inform limitation and provide targeted/regional tools / validation efforts together with EO product

0v · Transparent processing chain (all steps!!)

0v · By ensuring all ESA-funded projects deliver clear uncertainty in their products.

0v · Provide aggregate uncertainty layers for maps and products

0v · EO uncertainty to statistical units adequately

0v · Provide not only the uncertainty also the error

0v · Always show EO-derived stats that include error bars / uncertainty

0v · One uncertainty layer for each product in the chain (EO-part)

0v · Generate default visualizations that include errors / uncertainty e.g. in the COSE

0v · Make all EO products a combination of: - The product - The uncertainty layer

0v · Link example studies with the data and their uncertainty assessment + methods used

0v · Uncertainty clear to find in metadata with method provided

0v · Metadata!!

0v · Define common uncertainty framework

0v · A standard for uncertainty fields in metadata

0v · Make it mandatory to explicit uncertainty throughout the value chain - Use uncertainty metadata standard

0v · Communicate uncertainties with every product

0v · Reproducibility of the measure

0v · Define a clear standardized protocol for local agencies to perform validation

Board 3 (21 items · 7 votes)

HMW find the sweet spot between sharing uncertainty maps + validation + not dropping down the data sources making all sides comfortable?

- 1v · Training users on EO acquisition / processing to understand best usage**
- 1v · Work together with statistic office people, understand their language**
- 1v · Confidence intervals or flags — Highlight spatially regions that have insufficient data for indicator, require validation**
- 1v · Together with uncertainty maps add info on how this should be interpreted, so users won't draw their own conclusions**
- 1v · Improve visualisation of uncertainty to show where the products work the best and where not**
- 1v · Define a unified protocol for uncertainty communication, which is transparent about its geographical distribution**
- 1v · Provide interpretation of uncertainty + comparability (non-EO) to other stats data used**
- 0v · Uncertainty per step
- 0v · Define a protocol shared around the world
- 0v · Define it in the tender / specifications
- 0v · Focusing statistics on statistics & not map (ask me in case)
- 0v · Have the users in mind, not only the technology!
- 0v · Increase the exchange between user + producer of data
- 0v · Focus on increasing the quality of the maps for end-users purposes
- 0v · Bring together RS community and statisticians (Standardise the data publication ways -> globally would be preferable)
- 0v · Define the whole process from the ideation to the product
- 0v · Global (not just European) standards / sharing requirements
- 0v · Co-design "Solutions" with end users from beginning
- 0v · Define minimum requirements and how to measure or provide the information
- 0v · How to deal with uncertainty maps, given the need for transparency?
- 0v · How to transfer uncertainty maps into official statistics?

Board 5A (15 items · 11 votes)

Working HMW: HMW produce uncertainty levels with enough confidence to insert EO in statistics workflows?

- 3v · Work with end users and understand their needs**
- 3v · Recognized guideline of validation part of project requirements.**
- 3v · Ensure that uncertainty is propagated across the value chain with standardized protocols**
- 1v · Make specific methodo. choices displayed mandatory**
- 1v · Have a certification process if best practice is followed**
- 0v · Uncertainty level framework (???)
- 0v · Transparency about potential errors / assumptions / bias in methodology
- 0v · Increase funding for validation tasks
- 0v · Independent validation
- 0v · Understanding the transparency traceability of resources
- 0v · Validating using a probability sample
- 0v · Proper and well-designed im-situ data collection surveys
- 0v · Transparency on the full EO chain from data to service
- 0v · Use uncertainty propagation
- 0v · Independent & recognized certificat of EO products?

Board 5B (23 items · 7 votes)

HMW find a way to support the accessibility of the in-situ data reducing duplicity of resources & cost effectiveness?

- 3v · Creating recognition an incentive to provide & share data to data providers**
- 2v · Involve the data creators of the in-situ data so they are more willing to open/share their (e.g. NFI) data**
- 1v · Create in-situ data catalogue**
- 1v · Make mandatory for ESA-funded projects to provide ALL their reference data (in-situ) in a standard format.**
- 0v · Increase global coverage of in-situ stations**
- 0v · Annual campaigns shared among stakeholders for in situ data**
- 0v · Validation planned part of project finance, and public access part of project requirement.**
- 0v · Create a mechanism to credit contributions to in situ
- 0v · Try to benchmark what other sectors do to incentivize data sharing
- 0v · Reward systems for users providing in-situ data
- 0v · Proper data sharing agreement (explicit)
- 0v · Lower barriers for engagement of users to deliver in-situ
- 0v · Find better methods for dealing with different spatial properties
- 0v · I14Y once-only principle
- 0v · Citizen science in-situ campaigns
- 0v · Enough budget to keep validation possible (continuous)
- 0v · In sites data providers should disclose the location of measurement.
- 0v · Open data validation database
- 0v · Encourage colocated EO and in-situ data
- 0v · Enforce publishing of reference data (including metadata) in public funded projects
- 0v · EU policies to „force“ access to in-situ data
- 0v · Contractual obligation
- 0v · Reduce access barriers for public bodies -> contract only with certain sectors

Board 6 (42 items · 15 votes)

HMW get clear common (shared) specs how EO data/product has been produced?

- 4v · Following standard ATBD template**
- 4v · Shorter (Summary) version of ATBD report (ESA)**
- 2v · Collaboration to clarify concepts between producers and users**
- 2v · Define standard approaches and for each step define full reproducible pipelines (open source)**
- 2v · ATBD available**
- 1v · Outreach & promotion & dissemination of already agreed specs**
- 0v · We need more/better sharing / communication / collaboration!
- 0v · Expand the groups consulted when defining processing chains
- 0v · We need shared terminology & standards!
- 0v · Establish a task-force or working group EO -> stat
- 0v · Capacity building both ways (of EO producers too)
- 0v · Create new ISO standards
- 0v · Create common reference data
- 0v · Common repository of all relevant material
- 0v · Common guidelines on how to report methodology steps attached to E.O. data
- 0v · Data availability for replication
- 0v · Metadata clear definitions
- 0v · Clear data quality guideline
- 0v · Data Harmonization Hub
- 0v · Common terminology between different stakeholders
- 0v · We need an EO – statistics framework or standard led by authoritative orgs. (e.g. EC/UN)?
- 0v · Create single reference source for all methods
- 0v · Metrics from benchmarking
- 0v · Define a "Go-No-Go" quality check common to all E.O. data produced
- 0v · Reporting standards (e.g. ISO)
- 0v · Clear metadata standards
- 0v · Be pragmatic
- 0v · BUT!!! Need to be aware that we can't just redo everything for stats
- 0v · Better explain to stats community what is already done.
- 0v · Methods clearly defined (from in-situ collection if needed, to the final product)
- 0v · Dissemination of current registry specification of EO products
- 0v · Standards for processing graphs

Appendix D · Ideation

Board 6 continued

- 0v · Review what's available & create clear standards building on them
- 0v · Open source repository
- 0v · Github repository with all (algo, in-situ, etc.)
- 0v · Video guideline processing with example data
- 0v · Get CEOS to "quality check" data + products
- 0v · CEOS – Land Product Validation guidelines
- 0v · Better ATBD
- 0v · Action (guidelines are there)
- 0v · Lower barrier for using guidelines
- 0v · Make the use of abstract but technical method description a standard in EO (maybe like UML)